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(54) Method of reading pattern and optical signal reader

Verfahren zum Lesen von Mustern und optischer Signal-Leser

Méthode de lecture de motifs et lecteur optique de signal

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(73) Proprietor: KABUSHIKI KAISHA TOSHIBA  
Kawasaki-shi, Kanagawa 212-8572 (JP)

(72) Inventors:

- Sano, Kenji  
1-1 Shibaura 1-chome, Minato-ku Tokyo 105 (JP)
- Urano, Taeko I.  
1-1 Shibaura 1-chome, Minato-ku Tokyo 105 (JP)
- Nishizawa, Hideyuki  
1-1 Shibaura 1-chome, Minato-ku Tokyo 105 (JP)
- Saito, Mitsunaga  
1-1 Shibaura 1-chome, Minato-ku Tokyo 105 (JP)

- Todorí, Kenji  
1-1 Shibaura 1-chome, Minato-ku Tokyo 105 (JP)

(74) Representative: Waldren, Robin Michael  
MARKS & CLERK,  
57-60 Lincoln's Inn Fields  
London WC2A 3LS (GB)

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## Description

[0001] This invention relates to a method of reading a pattern such as a bar code pattern which is useful in postal service; in distribution business or in management of confidential documents or articles, and also relates to an optical system for reading signal from such a pattern.

[0002] US patent number 3,566,120 discloses a general method for providing links with code components of compounds having narrow absorption bands in the infrared on a substrate, and reading the coded information using infrared radiation.

[0003] In recent years, a system for automatically inputting information by making use of bar code has been studied in various fields of industry. For example, there has been an attempt to print bar code corresponding to zip code and address on the surface of mails such as postal cards so as to allow to sort mails automatically by reading the bar code on the mails, thereby enhancing the efficiency of postal service. There has been also proposed a system in hospital wherein bar code corresponding to medical chart is printed on the surface of a consultation ticket for the patient so that as soon as the bar code on the consultation ticket is read by bar code reader, the medical chart can be automatically transferred from file stacks to a doctor. Furthermore, the application of bar code is also studied for an automatic retrieval system of official documents in government office, for a management system for the entry and delivery of clothes in dry-cleaning business, for an automatic retrieval system of training record from a training card in driver's school, or for a storage system of various goods.

[0004] In the application of bar code for these systems, various problems are raised if the bar code is printed with the conventional black ink. For example, since characters indicating address are already written on the surface of mail, if the bar code array newly printed on the surface of mail is overlapped with these characters, the signals to be detected from the bar code may be accompanied with noise, thus making it difficult to read information correctly from the signals. This problem may become more serious when the length of the bar code array becomes longer for recording much information. Moreover, the black bar code printed on the mail not only spoils the appearance of the mail but may make the characters already written thereon unreadable.

[0005] Even if a color ink containing orange, blue or brown dye is employed in place of black ink for printing bar code, the same problem as in the case of bar code made of a black ink would be raised if the colored bar code is overlapped with the characters already written on the mail. Further, there are also problems that some of dyes are harmful to human body and that many dyes are easily subjected to photo-degradation.

[0006] With a view to solve these problems, novel material for forming bar code has been studied. For example, the employment of a fluorescent material which is

capable of absorbing ultraviolet light and emitting fluorescence in visible region is studied to form transparent bar code. In this case, the region including bar code is irradiated with ultraviolet light as excitation light to cause fluorescence in visible region to emit, and the resultant fluorescence is detected as signals.

[0007] European patent publication number 0 300 729 discloses a system where a transparent fluorescent or polymeric ink bar code is read by emitting ultraviolet or infrared radiation to the bar code and determining the difference in the intensity of light reflected by the bar code.

[0008] Further, we acknowledge that US-A-3566120 disclosed a method of reading a pattern as defined in the pre-characterising portion of Claim 1.

[0009] Since the bar code in this case is transparent in the ordinary conditions, the readability of the characters already written on the mail would not be hindered even if the bar code is overlapped with the characters. However, there is another problem that since white paper used for postal cards, for instance, generally contains fluorescent whitening agent, noise of considerable magnitude as compared with the signal from the bar code is detected from the paper, whereby deteriorating the S/N ratio.

[0010] Accordingly, an object of the present invention is to provide a method of reading a signal with a high S/N ratio from a transparent pattern (invisible pattern) which is free from any trouble in reading a signal from the pattern or in reading characters already written even if the pattern is overlapped with the characters.

[0011] Another object of the present invention is to provide an optical system for reading a signal from such a transparent pattern as described above.

[0012] The present invention provides a method of reading a pattern as defined in Claim 1.

[0013] In another aspect the present invention provides an optical system including a signal reader, as defined in Claim 3.

[0014] This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic view explaining the principle of a reader for a pattern formed according to the present invention;

FIG. 2 is a schematic view explaining another principle of a reader a pattern formed according to the present invention;

FIG. 3 is a schematic view explaining still another principle of a reader for a pattern formed according to the present invention;

FIG. 4 is a schematic view showing an example of an optical signal reader for a pattern formed according to the present invention;

FIG. 5 is a schematic view showing another example of an optical signal reader for a pattern formed according to the present invention;

FIG. 6 is a schematic view showing still another example of an optical signal reader for a pattern formed according to the present invention;

FIG. 8 is a perspective view showing a bar code character rings;

FIG. 9 is a plan view illustrating the position of printing a transparent bar code pattern onto a shirt;

FIG. 10 is a plan view illustrating the position of printing a transparent bar code pattern onto a bed sheet;

FIGS. 11A to 11C respectively show in plan view a mark to be formed in the vicinity of a transparent bar code pattern; in accordance with the present invention;

FIG. 12 is a schematic view showing the construction of an optical signal reader for reading a transparent pattern with a colored mark in the vicinity thereof;

FIG. 13 is a schematic view showing the construction of another example of an optical signal reader for reading a transparent pattern with a transparent mark in the vicinity thereof;

FIGS. 14A to 14C respectively show in plan view a transparent bar code pattern and a punch hole to be formed on a prepaid card.

[0015] As mentioned above, the invention provides a method of reading a pattern comprising steps of heating or irradiating with infrared light a substrate on which a pattern that is transparent in the visible region is formed, said pattern containing a polymer, or a low molecular weight compound, having in either case a cyano group and being capable of absorbing infrared light of a specific wavelength; and detecting infrared light from said pattern; characterized in that a mark is formed in the vicinity of the pattern region on said substrate, the mark being coloured or else comprising a fluorescent material capable of emitting visible light upon absorption of ultraviolet light.

[0016] As for the shape of the pattern to be formed on the substrate according to this invention, there is no particular restriction, i.e., the shape of pattern may be a linear bar code symbol consisting of bars and spaces, or any other shape such as a two-dimensional symbol. The pattern formed on a substrate according to this invention is made of a transparent material, i.e., a material that is colorless and transmits light in the visible region. Therefore, there is no possibility of raising problems of difficulties in reading signals from the pattern and reading characters that are already written even if the pattern is overlapped with the characters, unlike the conventional methods in which a black ink or a colored ink containing a dye is used for the pattern.

[0017] In the present invention, the material used for the pattern such as bars of a bar code to be formed on a substrate is a transparent material containing a compound having a cyano group. Generally, the material containing a polymer as a main component may be used

for forming the pattern. More specifically, a polymer having cyano groups or a mixture comprising any base polymer and a low molecular-weight compound having cyano groups may be used for forming the pattern. Specific examples of polymer having cyano groups include polyacrylonitrile and acrylonitrile-based copolymer. An example of the low molecular-weight compound having a cyano group is cyanobiphenyl.

[0018] These materials are dissolved in a suitable solvent, and the resultant solution is printed on a substrate by a suitable printing method and dried thus forming a pattern. Although there is not any particular restriction as to the method of printing the pattern, the employment of a high speed printing method is preferred. Examples of such a high speed printing method are a printing method by an ink jet printer, a bubble jet printer or an ultrasonic ink jet printer using a transparent ink formed of a solution containing a polymer as a main component; a printing method by an electrophotographic printer according to the Carlson process using a transparent toner containing polymer particles as a main component; and a printing method by a bar code character rings.

[0019] Cyano group exhibits a characteristic absorption at the region of 2260 to 2240  $\text{cm}^{-1}$ , which can be distinguished from the absorption spectra of other substituent groups. Meanwhile, paper used for mail, for example, does not contain cyano group. Therefore, the employment of an infrared absorbing agent containing a cyano group is advantageous in enhancing the S/N ratio.

[0020] In the present invention, the signal of the transparent pattern can be read by making use of an optical signal reader comprising means for conveying a substrate on which a transparent pattern containing a material capable of absorbing infrared light is formed, means for heating or irradiating with infrared light a region of the pattern formed on the substrate, and means for detecting infrared light from the region of pattern.

[0021] There is no limitation regarding the means for heating or irradiating with infrared light. For example, an infrared lamp may be employed, a hot air may be blown to the substrate, or the substrate may be contacted with a heat source such as a heat roller or a heat sink. As for the means for detecting infrared light from the pattern thus heated or irradiated with infrared light, a thermoelectric cooling type HgCdTe detector may be employed for instance. The pattern may be visualized by making use of a thermal image analysis system so as to perform an image analysis of the visualized pattern by means of an image analyzer. When infrared light reflected from the pattern region is detected, the heating means or infrared-irradiating means should preferably be arranged symmetrical with the detecting means. When the pattern is detected by a method other than detecting the infrared light reflected from the pattern, there is not any particular restriction regarding the arrangement of the heating means or infrared-irradiating means in relative to the detecting means, since the infrared light radiated from the

pattern region have no directivity.

[0022] The method of reading signals from the pattern according to this invention will be further explained with reference to an example where a material having a cyano group is employed as an infrared-absorbing agent.

[0023] Referring to FIG. 1, a pattern 2 containing an infrared-absorbing agent having a cyano group is formed on the surface of a substrate 1. An infrared lamp 11 is arranged so as to irradiate a region including the pattern (hereinafter referred to as a pattern region) on the substrate with infrared light through a filter 13. If the filter 13 is capable of transmitting infrared light having a wavelength of 4 to 5  $\mu\text{m}$ , the pattern containing an infrared-absorbing agent having a cyano group can be selectively heated, but the substrate 1 is not heated so much. After the pattern 2 is heated for a sufficient time to bring about a substantial difference in temperature between the pattern 2 and the substrate 1, the substrate 1 is conveyed so that the infrared light radiated from the pattern is detected by means of an infrared detector 12 to perform the reading signal from the pattern.

[0024] In the embodiment shown in FIG. 2, the substrate 1 is entirely heated by the infrared lamp 11, and after the pattern is heated for a sufficient time to bring about a substantial difference in temperature between the pattern 2 and the substrate 1, the substrate 1 is conveyed so that the infrared light of specific wavelength radiated from the pattern is detected by means of the infrared detector 12 through a filter 14 to perform the reading signal from the pattern. The heating of the entire surface of substrate 1 may be performed by blowing a hot air onto the surface or by contacting a hot plate to the surface of substrate for a sufficient time to bring about a sufficient temperature rise of the pattern 2.

[0025] Since a filter which is capable of transmitting only infrared light of specific wavelength region is disposed at the infrared-irradiation side or at the detector side, it is possible to further enhance the S/N ratio upon reading signal from the pattern. Namely, in the case of embodiment shown in FIG. 1, for the purpose of selectively heating the pattern made of a material having cyano group, the filter capable of transmitting only infrared light of 4 to 5  $\mu\text{m}$  in wavelength is disposed in front of the infrared lamp as a heating means. On the other hand, in the case of embodiment shown in FIG. 2, for the purpose of selectively detecting infrared light of specific wavelength radiated from the pattern, a similar kind of filter as mentioned above which is capable of transmitting only infrared light of 4 to 5  $\mu\text{m}$  in wavelength is disposed in front of the detector. These filters may be disposed in front of both infrared lamp and detector.

[0026] The reading signal from the pattern may be performed as shown in FIG. 3. Namely, the infrared lamp 11 and the infrared detector 12 are disposed symmetrical with each other with the pattern region on the substrate being located therebetween. The substrate is conveyed at a high speed while the pattern region on the substrate 1 is irradiated through the filter 13 with in-

frared light corresponding to the absorption wavelength region peculiar to the cyano group from the infrared lamp 11, and the infrared light corresponding to the absorption wavelength region of cyano group reflected from the pattern region is detected by an infrared detector 12 through the filter 14, thereby to perform the reading signal from the pattern. In this case, the irradiation time of infrared light is very short so that any sufficient difference in temperature between the substrate and the pattern would not be brought about. However, since the magnitude of infrared light reflected from the pattern is relatively low due to the absorption by cyano group and the magnitude of infrared light reflected from the substrate is relatively high, it is possible to read signal from the pattern. In this case, the ON/OFF of the signals to be detected becomes opposite to the case shown in FIG. 1 or 2.

[0027] It is possible to employ an apparatus as shown in FIG. 4, wherein an infrared light source, an infrared detector, a beam splitter 21 and a filter 22 are integrated together. The infrared light from the light source is reflected by the beam splitter 21 and then passed through the filter 22 to irradiate the pattern region on the substrate 1. The infrared light reflected from the pattern 2 are passed through the filter 22 and the beam splitter 21 to be detected by an infrared detector.

[0028] It is also possible to employ an apparatus shown in FIG. 5, wherein a heater 31 and an infrared detector 32 are integrated together. The pattern region on the substrate 1 is heated by the heater 31, and then the infrared light radiated from the pattern is detected by an infrared detector 32.

[0029] It is also possible to read signal from the pattern by employing an apparatus shown in FIG. 6. A three-dimensional object 41 having a pattern printed thereon is conveyed by a conveyor 42 while being heated by a heater 51. Then the infrared light radiated from the pattern thus heated are detected by an infrared detector 52 of a thermal image analysis system and displayed on a monitor 53 thus visualizing the pattern itself, the visualized pattern being image-analyzed by means of an image analyzer 54 (a computer).

[0030] Although the above explanations are mainly concentrated on the cases where transparent bar code pattern is printed on a paper sheet, this invention is also applicable to cloth. Namely, transparent bar code formed of a material containing a compound having a cyano group may be printed on clothes. In this case, the transparent bar code can be printed on clothes by making use of a bar code character rings shown in FIG. 8. The bar code character rings has a number of rotatable rings 71 assembled coaxially, each ring 71 being provided with a plurality of nozzles 71a corresponding to bar pattern. A molten polymer is supplied to the bar code character rings from feed pipe 72 and kept, while being heated, in the interior of the character rings. These rings are suitably rotated so as to set a combination of bar pattern, and then the molten polymer is extruded from

each of the nozzles thereby performing a hot melt coating to form a bar code pattern on the surface of clothes. [0031] A bar code pattern may be formed on the surface of clothes by sewing a thread made of a polymer fiber containing cyano group such as polyacrylonitrile fiber. The sewing of the thread on the surface of clothes can be easily performed by using a computer-controlled sewing machine in which data on the bar code pattern are stored. In this case, it is possible to prevent the sewed thread from standing out of the clothes by employing a thread of the same color as that of the clothes. The thread formed of acrylic fiber is unharmed to human body and is free from discoloring or decoloring by sweat. The bar code made of the thread of acrylic fiber would not be damaged and can be read without fail even if dry cleaning, washing with water, spin-drying or sunlight drying is repeated a number of times.

[0032] There is any particular restriction with respect to the kind of bar code. However, the employment of two-dimensional symbol such as Data Code or Veri Code is preferable because the bar code is formed on a uneven surface of cloth. Furthermore, these two-dimensional symbols are advantageous in recording more information.

[0033] According to this invention, the management of dry cleaning service by making use of bar code can be performed as follows.

[0034] A bar code pattern is formed on an outer portion of cloth when the cloth is properly folded. For example, in the case of shirt, a bar code pattern is formed, as shown in FIG. 9, on the pocket 83 or the back 84 of the shirt 81, either of which can be seen through the wrapper 82. In the case of a bedsheet, a bar code pattern is formed, as shown in FIG. 10, on a portion 86 (upper right portion in the drawing) of the bedsheet 85, which comes out to an outer surface as the bedsheet is folded. The bar code can be read by using optical readers as shown in FIGS. 1 to 6.

[0035] By providing clothes with a bar code for recording information on client or the commodity, it is possible to manage the clothes effectively. Moreover, when such clothes are collected in a laundry, it is possible to read the bar code attached to the clothes thereby permitting the clothes to be processed by means of computer at the counter of laundry so as to make it possible to rapidly issue a receipt recording a charge and delivery date on the basis of information from the bar code.

[0036] In the present invention, the transparent pattern and the infrared light for detection are invisible to the naked eye. Therefore, it may be difficult to irradiate a transparent bar code region with infrared light properly. This problem however can be solved by the present invention of forming a mark indicating the region of the transparent bar code. This mark may be a coloured mark which may contain a dye, or a transparent mark containing a fluorescent material capable of emitting visible light upon being excited with ultraviolet light.

[0037] Specific examples of such a mark are shown

in FIGS. 11A to 11C. In these drawings, the transparent bars are illustrated as black bars for convenience sake. In FIG. 11A, the region of transparent bar code 2 is surrounded by a frame line 3a. In the cases of FIGS. 11B or 11C, a mark 3b or 3c is printed at the beginning of the region of transparent bar code 2. In some cases, a transparent mark containing a fluorescent material or a colored mark may be printed so as to cover the region of the transparent bar code.

[0038] When a colored mark is printed in the vicinity of the transparent bar code, a reader provided with a visible guiding beam source is employed. One example of such a reader (a handy scanner) is shown in FIG. 12. This handy scanner 91 is provided, in addition to an infrared light source 93 and an infrared detector 94, with visible guiding beam source 95 in parallel with the infrared light source 93. An optical fiber 97 is connected to the handy scanner 91. Since this visible guiding beam should preferably be excellent in directivity, the employment of laser beam is preferable. According to this handy scanner, it is possible to accurately irradiate the region of the transparent bar code with infrared light by preliminarily irradiating the beginning point of the transparent bar code indicated by the colored mark with the guiding beam.

[0039] When a transparent mark containing a fluorescent material is printed in the vicinity of the transparent bar code, a reader provided with a visible guiding beam source and an ultraviolet light source is employed. One example of such a handy scanner is shown in FIG. 13. This handy scanner is similar in construction to that shown in FIG. 12 except that it is further provided with an ultraviolet light source 96. According to this handy scanner, the transparent mark is irradiated with ultraviolet light to be visualized, and then the beginning point of the transparent bar code indicated by the transparent mark is irradiated with the guiding beam thereby making it possible to irradiate the transparent bar code region with infrared light accurately.

[0040] The method of detecting infrared light from the transparent pattern as explained above can also be utilized as a method for preventing the counterfeiting of certificates or prepaid cards.

[0041] There have been proposed several methods for preventing the counterfeiting of certificates, etc. However, none of these methods have been proved to be satisfactory. For example, a method of forming a relief on a certification photograph by strongly pressing a stamp thereon is known since a long time ago. However, it is quite possible to form almost the same relief as that of the true one by molding the shape of the true relief with clay thereby manufacturing a stamp. A method of stamping a tally impression on a certification photograph is also known since a long time ago. However, the counterfeiting of the image of tally impression can be performed now without difficulty by making use of electronic means. A method of adhering a seal printed with a highly elaborate picture or with a hologram on a cer-

tification photograph is also known. It may be possible for a counterfeiter to peel off the seal and the true photograph, and adhere a false photograph in place of the true photograph. However, it may be very difficult for the counterfeiter to reproduce the seal in high precision. Namely, these methods are based on the idea of inhibiting the counterfeiting by increasing the counterfeiting cost. However, since the manufacture of such a high precision seal requires a technique of high level as well as a high manufacturing cost, this method is not widely applicable to general certificates.

[0042] It may be conceivable for the prevention of counterfeiting to print, in addition to visible information such as photograph, tally impression or signature for certifying a document to be genuine, a pattern corresponding to the visible information by making use of a transparent ink containing a fluorescent material on the surface of the document. In this method, if the information obtained from the transparent pattern agrees with the visible information, then the document is confirmed to be genuine. However, the presence of such a transparent pattern (such as bar code) can be easily recognized by irradiating the certificate with ultraviolet light by employing an inexpensive UV lamp (black light) which is commercially available. Furthermore, it is relatively easy for a counterfeiter to counterfeit the visible information and then to form a transparent pattern imitating the original pattern by making use of fluorescent paint available in the market.

[0043] In the present invention, a transparent pattern is formed on a certificate, the pattern being made of a material capable of absorbing infrared light of specific wavelength, and corresponding to the visible information such as a photograph, a tally impression, or a signature for certifying the document. The confirmation of the document is performed by heating or irradiating with infrared light the transparent pattern region so as to detect infrared light from the transparent pattern region, and then comparing the information obtained from the transparent pattern with the visible information. In this case, the transparent pattern may be printed at a position apart from that of the visible information. Alternatively, a transparent film may be formed on the visible information, and the transparent pattern corresponding to the visible information may be formed on this transparent film. The shape of the transparent pattern may be a bar code or an image corresponding to the visible information.

[0044] A specific example of the above method will be described below. For example, when a document with a seal impression thereon is submitted by an applicant and is approved by an authorized person, a replication of the image of the seal impression is printed on the document by the authorized person by making use of a transparent ink. The existence of the transparent pattern of replication is invisible to the naked eye. Whether the certification document is genuine or not is determined as follows. First, the image of the seal impression is read

by means of an image reader. On the other hand, the transparent pattern is read by means of a reader provided with an infrared light source and an infrared detector. When information obtained from the genuine document is processed with a computer, the image of the seal impression would be found to be identical with the image of the transparent pattern. However, if only the seal impression on the document is counterfeited by a counterfeiter who does not know the existence of the transparent pattern, the information on the transparent pattern cannot be detected by the above reader. Therefore, it is found that the document is counterfeited. In order to counterfeit such a document as described above, it required to provide an optical reader using infrared light, a computer technology and a printer, so that the counterfeiting cost would be very high, thus suppressing any attempt to counterfeit a document. Further, the region of the transparent pattern may be covered with a transparent film. In this case, it is impossible to find out the transparent pattern to examine contact angles of water droplets, resulting in improvement of security.

[0045] Next, a method of preventing counterfeiting of a prepaid card will be explained. In the case of telephone card, the remaining sum or remaining number of telephone calls available for use is recorded in the form of magnetic information, and also it is approximately indicated by a punch hole for the convenience of the user. The counterfeiting of such a prepaid card may be prevented by comparing the magnetic information recorded therein with the information obtained from the position of the punch hole, thereby checking the consistency of the remaining number of telephone calls. However, it is possible for a counterfeiter to decode the magnetic information recorded in the prepaid card by means of a magnetic reader and rewrite the magnetic information as well as to hide the punch hole with an adhesive tape. Thus, the counterfeiter can easily counterfeit the prepaid card such as telephone card.

[0046] In a method of preventing counterfeiting of prepaid card there is formed, on the prepaid card, a plurality of transparent patterns corresponding to remaining sums, for example, remaining numbers of telephone calls, and one of said patterns corresponding to a remaining sum available for use is punched at the time when the prepaid card is used, thereby making a hole.

[0047] For example, as shown in FIG. 14A, on a prepaid card, transparent bar code characters made of a material containing an infrared absorbing agent are formed corresponding to the remaining numbers of telephone calls. In this drawing, the transparent bars are depicted as black bars for convenience sake. However, it should be understood that as a matter of fact these bars are invisible to the naked eye. The numerals, for example, 0, 1, 2, etc., depicted at the lower portion of the drawing represent the remaining numbers of telephone calls, i.e. 0%, 10%, 20%, and so on. As shown in FIGS. 14B and 14C, at the time when the prepaid card

is used, the region of transparent bar code character corresponding to the remaining number of telephone calls is punched, thereby making a hole.

[0048] In order to check the remaining number of telephone calls of this prepaid card, used is an optical reader comprising an infrared light source and an infrared detector. Namely, the transparent bar code is irradiated with infrared light while scanning so as to pass on the punch holes, and infrared light radiated or reflected from the region of bar code is detected by the detector. In this case, it is impossible to read a portion of the bar code pattern which has been punched. Therefore, the remaining number of telephone calls available for use can be indicated by the minimum number that cannot be read. For example, referring to FIG. 14B, the transparent bar code character corresponds to the number 1 cannot be read, indicating that the remaining number of telephone calls available for use is not more than 10%. In the case of FIG. 14C, two transparent bar code characters corresponds to the numbers 2 and 0 cannot be read, indicating that the remaining telephone calls available for use is 0%.

[0049] It may be possible for a counterfeiter to decode the magnetic information recorded in the prepaid card by means of a reader, to rewrite the magnetic information so as to make the remaining telephone calls available for use to be 100%, and to hide the punch hole with an adhesive tape. However, it would be very difficult to reproduce the transparent bar code characters because they are invisible to the naked eye. Therefore, as for a prepaid card on which the transparent bar code characters are not reproduced, although the remaining number of telephone calls obtained from the rewritten magnetic information indicates 100%, the remaining number of telephone calls available for use would be 0% according to the reading of the transparent bar code characters. From this discrepancy, the counterfeiting of the prepaid card can be easily revealed.

#### EXAMPLES

[0050] This invention will be further explained with reference to the following examples.

##### Example 1

[0051] Polyacrylonitrile powder is dispersed as an infrared-absorbing agent in a 5 wt% aqueous solution of polyvinyl alcohol at a ratio of 2 wt% based on the polyvinyl alcohol. By an ink jet printer using the dispersion as an ink, a bar code pattern consisting of ten parallel bars, each having a width of 4 mm and a length of 20 mm with a spacing of 4 mm, is formed on a plain paper having visible characters printed in advance. When the paper is observed from the front thereof, the printed characters on the paper can be identified without any trouble.

[0052] Then, this paper is subjected to an experiment

for reading the bar code pattern by heating it and detecting with a thermoelectric cooling type HgCdTe detector. The specification of this detector is: allowable temperature range 0 to 250°C; allowable wavelength region 3 to 5.3  $\mu\text{m}$ ; minimum detectable dimension 85  $\mu\text{m}$ ; and operation distance 13 mm. Specifically, a 100 W infrared lamp is positioned 3 cm above the paper to heat the paper. After the paper is heated, the window of the detector is immediately disposed in parallel with the surface of the paper, and the detector is scanned over the surface of the paper at a velocity of 3 m/sec to detect the ON/OFF of the signals. As a result, ON signals are obtained due to heat radiated from the pattern of bars. Further, when a filter for selectively transmitting infrared light of 4 to 5  $\mu\text{m}$  in wavelength is disposed in front of the detector and the monitoring of the bar code pattern is performed in the same manner as described above, the S/N ratio has been enhanced by 10 times.

[0053] Next, the paper is placed on a hot plate heated to 80°C, and a monitoring is performed by making use of a thermal image analysis system (Thermovision 900, Toyo Technica Co.). As a result, it is possible to identify the pattern of bars on the monitoring CRT. Likewise, this paper is heated via a filter for selectively transmitting infrared light of 4 to 5  $\mu\text{m}$  in wavelength by means of an infrared lamp, and a monitoring is performed by making use of the same thermal image analysis system as mentioned above. As a result, it is confirmed on the monitoring CRT that the pattern of bars is selectively heated. As explained above, since it is possible to read the bar code pattern without requiring a scanner, the bar code pattern can be taken up as an image by a computer thereby allowing the image of the bar code pattern to be analyzed.

##### Example 2

[0054] Cyanobiphenyl is dispersed as an infrared absorbing agent in a 5 wt% aqueous solution of polyvinyl alcohol by making use of sodium stearate as a surfactant. The content of cyanobiphenyl is 1 wt% based on the polyvinyl alcohol. By an ink jet printer using the dispersion as an ink, a bar code pattern consisting of ten parallel bars, each having a width of 4 mm and a length of 20 mm with a spacing of 4 mm, is printed on a plain paper having visible characters printed in advance. When the paper is observed from the front thereof, the printed characters on the paper can be identified without any trouble.

[0055] Then, this paper is heated by means of a hair dryer. After this paper is heated, the window of a thermoelectric cooling type HgCdTe detector is immediately disposed in parallel with the surface of the paper, and the detector is scanned over the surface of the paper at a velocity of 3 m/sec to detect the ON/OFF of the signals. As a result, ON signals are obtained due to heat radiated from the pattern of bars.

## Example 3

[0056] Polyester pellet and polyacrylonitrile pellet are respectively pulverized into particles having an average particle size of 11  $\mu\text{m}$ , thereby obtaining a toner containing no pigment. The ratio of the polyester particles to the polyacrylonitrile particles is controlled to 1:1 by weight. By a laser beam printer using the mixture as a toner, a bar code pattern consisting of ten parallel bars, each having a width of 4 mm and a length of 20 mm with a spacing of 4 mm, is printed on a plain paper having visible characters printed in advance. When the paper is observed from the front thereof, the printed characters on the paper can be identified without any trouble.

[0057] Then, a 100 W infrared lamp is positioned 3 cm above the paper to heat the paper. After the paper is heated, the window of the thermoelectric cooling type HgCdTe detector is immediately disposed in parallel with the surface of the paper, and the detector is scanned over the surface of the paper at a velocity of 3 m/sec to detect the ON/OFF of the signals. As a result, ON signals are obtained due to heat radiated from the pattern of bars.

## Example 4

[0058] A thread of polyacrylonitrile fiber (acrylic fiber called Zacron, Mitsui Toatsu Co.) sewed on clothes each made of nylon, polyester, cotton or silk to form a bar code pattern by making use of a sewing machine. In this case, formed is the bar code of CODE 39 system where alphanumeric characters from 0 to 9 and from a to g are represented by narrow bars having a width of 2 mm and wide bars having a width of 6 mm.

[0059] Then, the clothes with the bar code formed of a thread of acrylic fiber is irradiated with infrared light via a filter capable of transmitting an infrared light of around  $2225\text{ cm}^{-1}$  from a siliconite heating element, thereby selectively heating the bar code pattern. This bar code pattern is then observed as an image by making use of Thermovision 900 (Toyo Technica Co.). On the CRT screen, the portions where the threads exist are displayed in white, whereas the portions without threads are displayed in black. However, it is possible to display the color tone of the general bar code by reversing the color tone of the image. Thus, it is possible to read the bar code information by an image processing with a computer.

[0060] Since the acrylic fiber cannot be dissolved by water or by a chlorinated organic solvent, it is possible to read the bar code information in the same manner as mentioned above even after washing with water in a washing machine and sunlight drying for three hours or after dry-cleaning with a dry cleaner.

[0061] As a matter of fact, a shirt attached with a cloth 2 cm x 5 cm in size with a bar code formed by sewing a thread of acrylic fiber is subjected to a ten-time repetition of a dry cleaning followed by ironing, and subsequently

the reading of the bar code is performed, finding that the bar code on the cloth can be read without any trouble.

[0062] In another test, the samples of the aforementioned cloth are exposed to UV light from a high pressure mercury lamp for 30 days, and subsequently the reading of the bar code from the samples is performed, finding that it is also possible to read the information from every samples without any trouble.

[0063] When polyacrylonitrile (Zacron, Mitsui Toatsu Co.) containing 10% by weight of tributyl phosphate as a plasticizer is employed for printing a bar code of CODE 39 system by making use of a bar code character rings which is capable of heating up to  $200^\circ\text{C}$ , the almost the same results as explained above can be obtained.

## Example 5.

[0064] Characters of TOSHIBA 96110 are printed with a black ink on a plastic card made of polystyrene having a thickness of 1.9 mm. Then, a polyethylene film 8  $\mu\text{m}$  in thickness is laminated on this plastic card and heat-sealed thereon at a temperature of  $170^\circ\text{C}$ . On the other hand, a styrene-acrylonitrile copolymer (weight ratio = 7:3, Aldrich Co.) is dissolved in 1,1,2-trichloroethylene at a ratio of 1 wt% by weight to prepare a solution, which is then used as an ink for an ink jet printer, and a transparent bar code of CODE 39 system corresponding to the characters of TOSHIBA 96110 is printed on the polyethylene film.

[0065] It is impossible to recognize the presence of the transparent bar code on the card with naked eye. The card with the bar code is irradiated with infrared light via a filter capable of transmitting an infrared light of around  $2225\text{ cm}^{-1}$  from a light source apart from the card by 2 cm for 30 seconds, thereby selectively heating the bar code pattern. The infrared light radiated from the bar code pattern is then detected via a filter with an MCT detector. The speed of scanning is set to 1 cm/sec. As a result, the bar code can be displayed on an oscilloscope where regions indicating infrared signals and regions indicating no infrared signal are clearly distinguished. These signals are then decoded to obtain information of TOSHIBA 96110. Meanwhile, the characters printed with a black ink on the same card are read by means of an image reader connected to a computer to obtain the information of TOSHIBA 96110. From the fact that the information obtained from the transparent bar code is identical with the printed characters, it can be confirmed that the card is genuine. On the other hand, in the case of a card that the transparent bar code is removed as a result of counterfeiting, the information from the transparent bar code cannot be obtained, thus determining the card as being counterfeited.

## Example 6

[0066] A stamp is put on a sheet of paper. Then, a polyethylene film 8  $\mu\text{m}$  in thickness is laminated on this

paper and heat-sealed thereon at a temperature of 170°C. Then, the image of the stamp is read using a scanner and stored in a computer. Subsequently, a transparent image corresponding to the image of the stamp is printed by making use of the same transparent ink and the same ink jet printer as described in Example 5.

[0067] It is impossible to recognize the presence of the transparent bar code on the paper with the naked eye. Then, the paper with the bar code is irradiated with infrared light via a filter capable of transmitting an infrared light of around 2225 cm<sup>-1</sup> from a light source apart from the paper by 2 cm for 30 seconds, thereby selectively heating the region of the image of stamp formed with a transparent ink. The infrared light radiated from this image formed of the transparent ink is then detected as an image via a filter by making use of a Thermovision 900 (Toyo Technica Co.). After this image is binarized to remove marginal blur, the resultant image is reversed and displayed on a computer display. On the other hand, the image of the stamp itself on the same paper is read using a scanner. In this case, it can be confirmed that the paper is genuine, if the image formed with the transparent ink is identical with the image of the stamp itself. On the other hand, in the case of a paper that the transparent image is removed as a result of counterfeiting, the information from the transparent image cannot be obtained, thus determining the paper as being counterfeited.

#### Claims

##### 1. A method of reading a pattern comprising steps of:

heating or irradiating with infrared light a substrate (1) on which a pattern (2) that is transparent in the visible region is formed, said pattern (2) containing a polymer, or a low molecular weight compound, having in either case a cyano group and being capable of absorbing infrared light of a specific wavelength; and detecting infrared light from said pattern (2);

characterized by locating a mark (3a, 3b, 3c) formed in the vicinity of the pattern (2) region on said substrate, the mark being coloured or else comprising a fluorescent material capable of emitting visible light upon absorption of ultraviolet light.

##### 2. A method according to Claim 1, including the step of reading the mark (3a, 3b, 3c).

##### 3. An optical system comprising:

a substrate (1) on which a pattern (2) that is transparent in the visible region is formed, said pattern (2) containing a polymer, or a low mo-

lecular weight compound, having in either case a cyano group and being capable of absorbing infrared light of a specific wavelength; and an optical signal reader comprising:

means (11, 31, 51, 93) for heating or irradiating with infrared light a region of said pattern (2) formed on said substrate (1); and

means (12, 32, 52, 92) for detecting infrared light with a wavelength in the region of 3 to 5.3µm radiated from said pattern (2);

characterized in that a mark (3a, 3b, 3c) is formed in the vicinity of the pattern (2) region on said substrate, the mark being coloured or else comprising a fluorescent material capable of emitting visible light upon absorption of ultraviolet light.

4. A system according to Claim 3, the reader including means (91, 96) for irradiating the mark (3a, 3b, 3c) with visible or ultraviolet light, depending on the mark being coloured or transparent and fluorescent, respectively, for reading the mark.

5. The method according to Claim 1 or 2, or an optical system according to Claim 3 or 4, in which said polymer having a cyano group is polyacrylonitrile or an acrylonitrile-based copolymer.

6. The method according to Claim 1 or 2, or an optical system according to Claim 3 or 4, in which said substrate (1) is made of cloth, and said pattern (2) is formed by sewing a thread made of fibers of polyacrylonitrile or acrylonitrile-based copolymer.

7. The method according to Claim 1 or 2, or an optical system according to Claim 3 or 4, in which said material constituting said pattern (2) has a higher thermal conductivity than that of said substrate (1).

8. An optical system according to Claim 3 or 4, in which at least either one of said means (11) for irradiating with infrared light and said means (12) for detecting infrared light is provided with a filter (13, 14) capable of transmitting infrared light of 4 to 5µm in wavelength.

#### 50 Patentansprüche

##### 1. Verfahren zum Lesen eines Musters, mit folgenden Schritten:

Erwärmen oder Bestrahlen eines Substrats (1) mit infrarotem Licht, auf dem ein Muster (2), das im sichtbaren Bereich transparent ist, ausgebildet ist, wobei das Muster (2) ein Polymer oder

- eine Verbindung mit niedrigem Molekulargewicht enthält, das/die in jedem Fall eine Cyan-Gruppe umfasst und imstande ist, infrarotes Licht einer spezifischen Wellenlänge zu absorbieren;  
Erfassen von infrarotem Licht von dem Muster (2);
- gekennzeichnet durch Anordnen einer Marke (3a, 3b, 3c), die in der Nähe des Bereichs des Musters (2) auf dem Substrat ausgebildet ist, wobei die Marke gefärbt oder ansonsten ein fluoreszierendes Material umfasst, das imstande ist, sichtbares Licht bei Absorption von ultraviolettem Licht zu emittieren.
2. Verfahren gemäß Anspruch 1 mit dem Schritt eines Lesens der Marke (3a, 3b, 3c).
3. Optisches System mit
- einem Substrat (1), auf dem ein Muster (2), das im sichtbaren Bereich transparent ist, ausgebildet ist, wobei das Muster (2) ein Polymer oder eine Verbindung mit niedrigem Molekulargewicht enthält, das/die in jedem Fall eine Cyan-Gruppe umfasst und imstande ist, infrarotes Licht einer spezifischen Wellenlänge zu absorbieren;  
und einem optischen Signalleser mit:
- einem Mittel (11, 31, 51, 93) zum Erwärmen oder Bestrahlen mit infrarotem Licht eines Bereichs des auf dem Substrat (1) ausgebildeten Musters (2);  
einem Mittel (12, 32, 52, 92) zum Erfassen von infrarotem Licht mit einer Wellenlänge in dem Bereich von 3 bis 5,3  $\mu\text{m}$ , das von dem Muster (2) abgestrahlt wird;
- dadurch gekennzeichnet, dass eine Marke (3a, 3b, 3c) in der Nähe des Bereichs des Musters (2) auf dem Substrat ausgebildet ist, wobei die Marke gefärbt oder ansonsten ein fluoreszierendes Material umfasst, das imstande ist, sichtbares Licht bei Absorption von ultraviolettem Licht zu emittieren.
4. System gemäß Anspruch 3, wobei der Leser ein Mittel (91, 96) zum Bestrahlen der Marke (3a, 3b, 3c) mit sichtbarem oder ultraviolettem Licht abhängig davon, ob die Marke gefärbt oder transparent bzw. fluoreszierend ist, zum Lesen der Marke umfasst.
5. Verfahren gemäß Anspruch 1 oder 2, oder ein optisches System gemäß Anspruch 3 oder 4, bei dem das Polymer mit einer Cyan-Gruppe Polyacrylnitril oder ein Acrylnitril-basierter Copolymer ist.

6. Verfahren gemäß Anspruch 1 oder 2, oder ein optisches System gemäß Anspruch 3 oder 4, bei dem das Substrat (1) aus Stoff hergestellt ist und das Muster (2) durch Nähen eines aus Fasern aus Polyacrylnitril oder Acrylnitril-basiertem Copolymer hergestellten Fadens gebildet wird.
7. Verfahren gemäß Anspruch 1 oder 2, oder ein optisches System gemäß Anspruch 3 oder 4, bei dem das Material, das das Muster (2) bildet, eine höhere thermische Leitfähigkeit als die des Substrats (1) aufweist.
8. Optisches System gemäß Anspruch 3 oder 4, bei dem mindestens eines von dem Mittel (11) zum Bestrahlen mit infrarotem Licht und dem Mittel (12) zum Erfassen von infrarotem Licht mit einem Filter (13, 14) versehen ist, das imstande ist, infrarotes Licht mit einer Wellenlänge von 4 bis 5  $\mu\text{m}$  durchzulassen.

#### Revendications

1. Procédé de lecture d'un motif comprenant les étapes consistant à :
- chauffer ou illuminer avec de la lumière infrarouge un substrat (1) sur lequel est formé un motif (2) qui est transparent dans la région visible, ledit motif (2) contenant un polymère, ou un composé à faible masse moléculaire, comportant dans les deux cas un groupement cyano et qui est capable d'absorber de la lumière infrarouge d'une longueur d'onde spécifique, et détecter de la lumière infrarouge provenant dudit motif (2),
- caractérisé par la localisation d'une marque (3a, 3b, 3c) formée au voisinage de la région du motif (2) sur ledit substrat, la marque étant colorée ou comprenant sinon un matériau fluorescent capable d'émettre de la lumière visible lors de l'absorption d'une lumière ultraviolette.
2. Procédé selon la revendication 1, comprenant l'étape consistant à lire la marque (3a, 3b, 3c).
3. Système optique comprenant :
- un substrat (1) sur lequel est formé un motif (2) qui est transparent dans la région visible, ledit motif (2) contenant un polymère, ou un composé à faible masse moléculaire, ayant dans les deux cas un groupement cyano et qui est capable d'absorber de la lumière infrarouge d'une longueur d'onde spécifique, et  
et un lecteur de signal optique comprenant :

un moyen (11, 31, 51, 93) destiné à chauffer ou à illuminer avec de la lumière infrarouge une région dudit motif (2) formé sur ledit substrat (1), et

un moyen (12, 32, 52, 92) destiné à détecter de la lumière infrarouge ayant une longueur d'onde dans la région de 3 à 5,3  $\mu\text{m}$ , rayonnée à partir dudit motif (2),

caractérisé en ce qu'une marque (3a, 3b, 3c) est formée au voisinage de la région du motif (2) sur ledit substrat, la marque étant colorée ou comprenant sinon un matériau fluorescent capable d'émettre de la lumière visible lors d'une absorption de lumière ultraviolette.

4. Système selon la revendication 3, le lecteur comprenant un moyen (91, 96) destiné à illuminer la marque (3a, 3b, 3c) avec de la lumière visible ou ultraviolette, suivant que la marque est colorée ou transparente et fluorescente, respectivement, afin de lire la marque.
5. Procédé selon la revendication 1 ou 2, ou bien système optique selon la revendication 3 ou 4, dans lequel ledit polymère comportant un groupement cyano est un polyacrylonitrile ou un copolymère à base d'acrylonitrile.
6. Procédé selon la revendication 1 ou 2, ou bien système optique selon la revendication 3 ou 4, dans lequel ledit substrat (1) est fait de tissu, et ledit motif (2) est formé en cousant un fil fait de fibres de polyacrylonitrile ou d'un copolymère à base d'acrylonitrile.
7. Procédé selon la revendication 1 ou 2, ou bien système optique selon la revendication 3 ou 4, dans lequel ledit matériau constituant ledit motif (2) présente une conductivité thermique supérieure à celle dudit substrat (1).
8. Système optique selon la revendication 3 ou 4, dans lequel au moins l'un ou l'autre dudit moyen (11) destiné à illuminer avec de la lumière infrarouge et dudit moyen (12) destiné à détecter de la lumière infrarouge est muni d'un filtre (13, 14) capable de transmettre de la lumière infrarouge d'une longueur d'onde de 4 à 5  $\mu\text{m}$ .

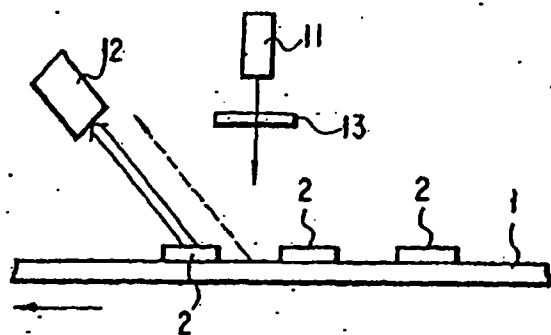


FIG. 1

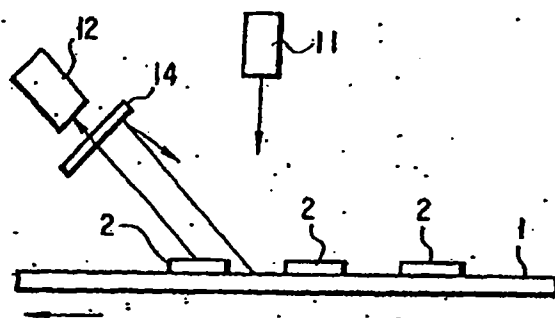


FIG. 2

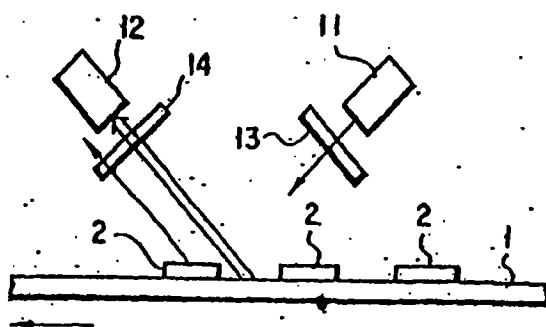


FIG. 3

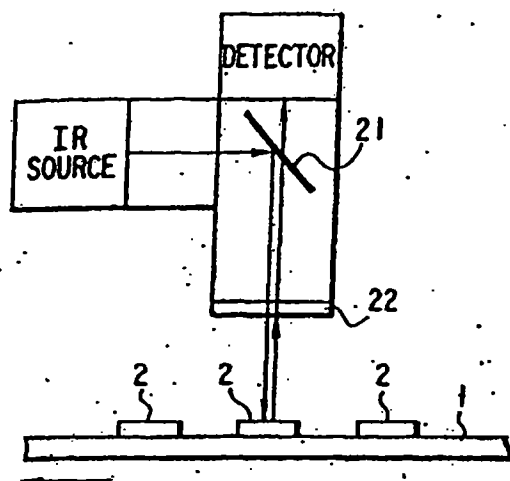


FIG. 4

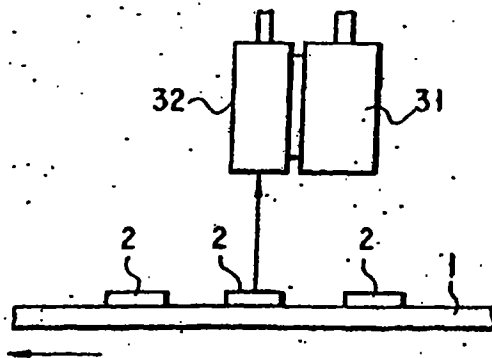


FIG. 5

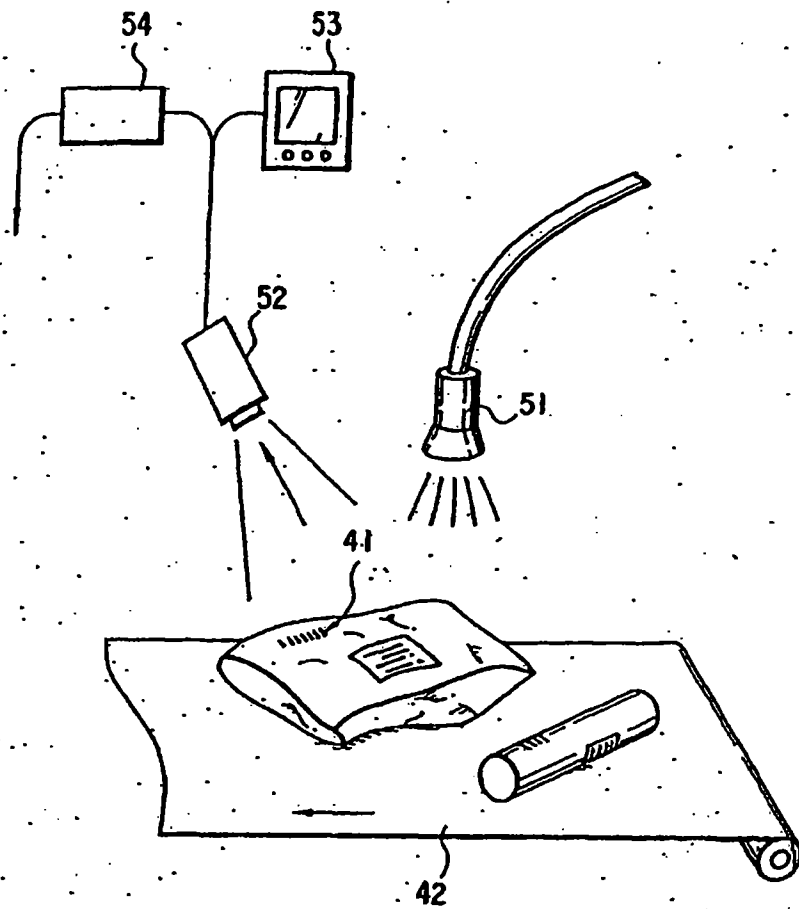


FIG. 6

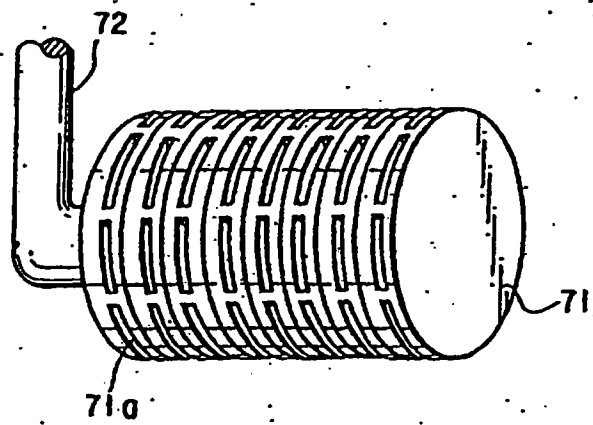


FIG. 8

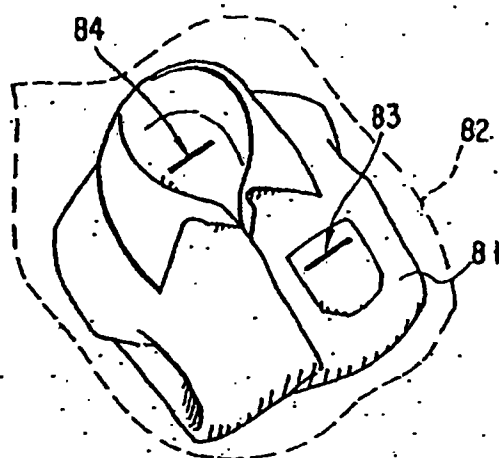


FIG. 9

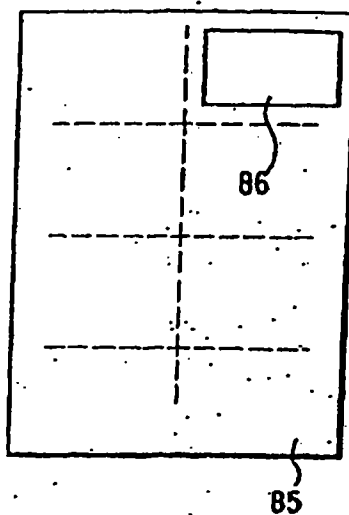


FIG. 10

FIG. 11A

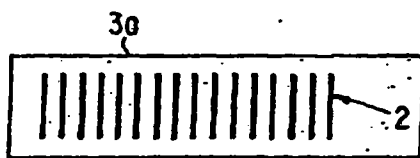
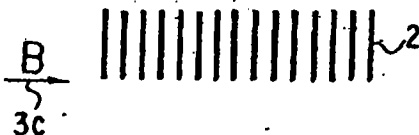


FIG. 11B



FIG. 11C



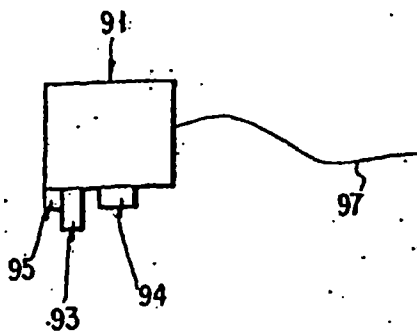


FIG. 12

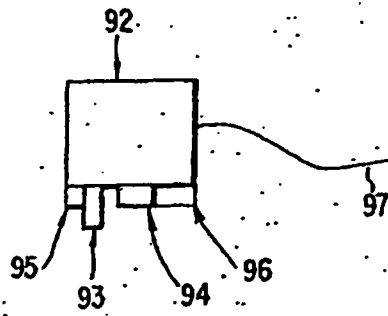


FIG. 13

FIG. 14A

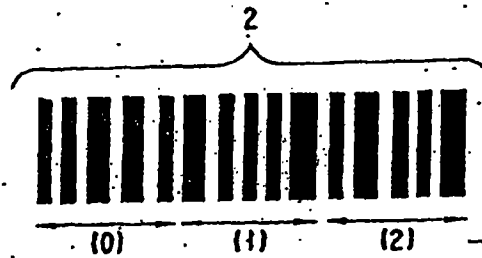


FIG. 14B

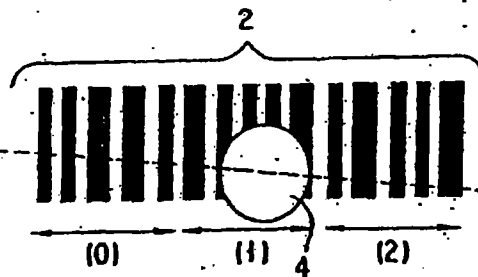


FIG. 14C

